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Specification and Drawings, as originally filed, with Application for Patent Serial No: **2,397,576**, on August 12, 2002, by **BIOSCRYPT INC.**, assignee of Curt Harkless and Eric M. Shrader, for "Finger Pattern Based Interchange Format ".

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Finger Pattern Based Interchange Format

We describe an approach for the compression of images such as a fingerprint involving a) a reduction in resolution, followed by b) cellular representation of the resulting down-sampled image.

1 Background

There are currently two generic forms of algorithms (and thus required interchange formats) for fingerprint matching: minutiae-based and pattern-based analyses. This invention describes an approach for storing and transmitting finger pattern interchange data for use with pattern-based fingerprint matching algorithms.

2 Definitions of Concepts and Special Terms

2.1 Raw Fingerprint Image

Fingerprint image as captured by a fingerprint sensor. This raw image will usually retain the full resolution and spatial extent permitted by the sensor.

2.2 Finger Pattern

Sub-portion and/or down-sampled version of the raw fingerprint image.

2.3 Finger Pattern Interchange Data

Data derived from the Finger Pattern and stored for subsequent matching with a candidate fingerprint.

2.4 Resolution

The number of picture elements (pixels) per inch (in dots per inch - dpi) in a sampled fingerprint image. Note that dpi is used throughout this document (1 dpi ≡ 0.039 pixels per mm).

2.5 Dimension

Number of pixels in either x- or y-direction.

2.6 Down-sample

Reduce the resolution of an image by re-sampling the image. This reduces the number of pixels accordingly.

2.7 Crop

Remove the outer regions of an image.

2.8 Pad

Embed an image in a larger array (usually filled with zeroes) to produce a resulting image of greater dimension.

2.9 Nyquist Frequency

Nyquist frequency is the (spatial) frequency at which exactly two samples of an image span a complete period of a (co)sinusoidal pattern.

2.10 Packed Data Format

Data are stored in a compacted bit form with no record separators or field tags - fields are separated by bit count only.

3 Finger Pattern Interchange Data

The proposed finger pattern interchange data is based on 1) conversion of the raw fingerprint image to a cropped and down-sampled finger pattern, followed by 2) cellular representation of the finger pattern image to create the finger pattern interchange data.

3.1 Step 1) Reduction in resolution

Pattern based fingerprint algorithms generally require less resolution than is output by sensors. Therefore, the first step in data reduction involves a re-sampling of the data to a lower resolution.

For example, fingerprint sensors such as the Authentec AF-S2 fingerprint sensor outputs 128x128 samples over 13x13 mm^2 (≅ 250 dpi). For pattern-based algorithms, sampling at 200 dpi is generally sufficient.

The input image is therefore re-sampled at 200 dpi to produce an image of lesser dimensions. Note that, prior to down-sampling, the original image may be padded or cropped such that the down-sample array is of dimensions that facilitate further processing.

An example of a re-sampled image is shown below in figure 1, where an original 128x128 image, sampled at 250 dpi, is first cropped to 120x120 pixels and then re-sampled to 200 dpi, to produce an image of dimensions 96x96 pixels.

a) b)

Figure 1. a) original 128x128 image sampled at 250 dpi. b) resulting image after cropping image in a) to 120x120 pixels, and re-sampling image at 200 dpi, to produce a 96x96 pixel dimensioned array.

The example shown above started with an image of only 250 dpi. Of course, the saving in data requirements at this stage is substantially greater for captured images of higher resolution, such as 500 dpi.

3.2 Step 2) Cellular Representation

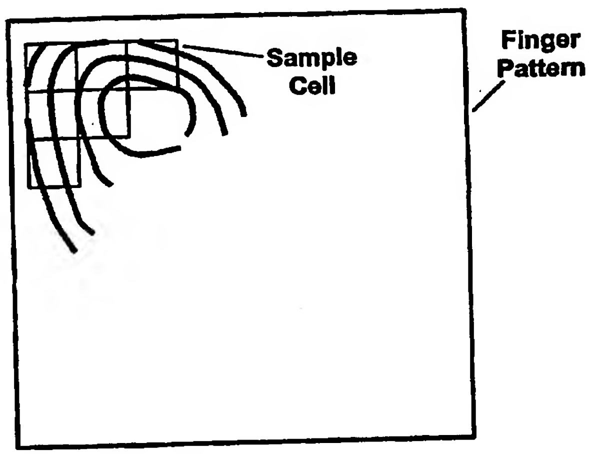

Figure 2. Diagram to illustrate Cellular Representation of Finger Pattern.

Cellular representation of the finger pattern data comprises dividing the finger pattern into a grid of cells of dimension, for example, 5x5 pixels. For this example, the grid contains 14x18 of such cells. This represents an image area of 70x90 pixels, or 8.9x11.4 mm. At each cell the finger pattern will be represented by one of 512 different cell structures, as described below.

3.2.1 Cell Structure

Each of the candidate cell structures for representing the local finger pattern data at each cell is defined by a two-dimensional cosinusoidal pattern (see figures 3 and 4). As such, each structure is defined by three parameters; the ridge angle, θ, the ridge spacing, λ, and the phase offset, δ, as illustrated in figure 3 b).

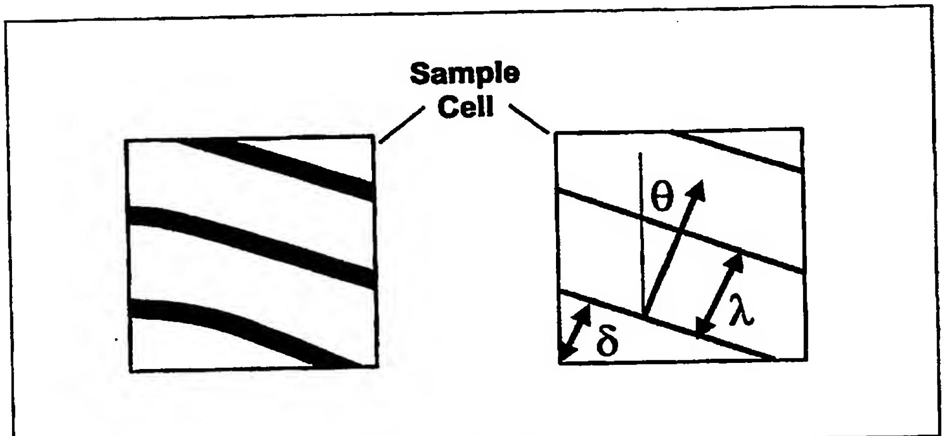

Figure 3. Cellular Representation of Finger Pattern.

The range of each of these parameters is given below:

θ: 0 to 180 degrees in 8 equal increments (i.e. 3 bits of information).
λ: 0 to 7/8 of Nyquist frequency, in 8 increments (i.e. 3 bits of information), i.e. for 200 dpi example, 0 to 3.4 lp/mm is represented.
δ: 0 to 360 degrees in 8 equal increments (i.e. 3 bits of information).

In this way each of the finger pattern cells is represented by the most similar of the 512 (8x8x8) permutations of cell structure. Each cell structure requires 9 bits of data storage – 3 bits for each of the three parameters (reduced from 5x5x8bits = 200bits per cell).

Figure 4 below demonstrates an example of the finger pattern a) and the resulting cell structure that is chosen to represent it b). Both of the images in this figure were enhanced in resolution for illustrative purposes.

a) b)

Figure 4. a) Example of the local finger pattern information in a cell, and b) the resulting cell structure chosen for representation.

In this manner, each of the finger pattern cells is represented by one of the 512 permutations of cell structure. The resulting data will comprise the public portion of the Finger Pattern Data Record. In this example, the finger pattern is represented by

14x18x9 bits (14 cells by 18 cells with 3 bits for each parameter), which requires 284 bytes of storage.

3.3 Quality

For each cell or group of cells, a quality parameter can also be stored. For example, each block of 2x2 of the cells defined above can be associated with a quality parameter (of say, 4 bits – permitting a range of 0 to 15, with higher numbers indicating better quality). In this example, with 14x18 cells, 7x9 = 63 quality parameter values will be required, adding just under 32 bytes to the interchange data. The quality parameter allows a weighting of the importance of various areas of the image.

Note that this data reduction process is not recommended for AFIS or minutiae-based systems for the reasons cited in the introduction as well as the following:
Minutiae points cannot exist in the center of a cell structure – therefore if minutiae were represented, there would be an average offset of 3 pixels in their location.
The cellular representation tends to confuse the definition of minutiae points between ridge endings and bifurcations that were present at the edges of cells.

Figure 5 below presents the finger pattern that has been represented by the cellular representation process.

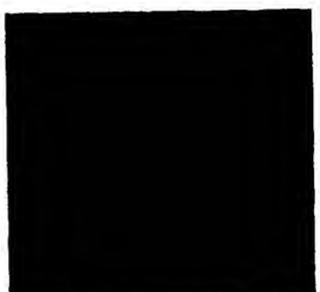

Figure 5. Cellular representation of the finger pattern.

While the preferred embodiment has been described with respect to fingerprints, it will be obvious to those skilled in the art that this data reduction process could be applied to other forms of images, such as iris images, using the appropriate cell structure.
Other aspects will be obvious to those skilled in the art; therefore the invention is defined in the claims.

We claim:

1. A method of obtaining a representation of an image, comprising:
   providing a stored set of cellular region representations;
   sub-dividing said image into a plurality of cellular regions;
   for each cellular region:

comparing image information of said each cellular region to each cellular region representation of a plurality of said cellular region representations, and,

based on said comparison, selecting one cellular region representation of said set of cellular region representations to represent said each cellular region.

2. The method of claim 1 wherein each cellular region representation of said set of cellular region representations comprises pattern information and wherein said image information of said each cellular region comprises pattern information.

3. The method of claim 1 wherein each cellular region representation of said set of cellular region representations comprises a set of values for a parameter set and wherein said image information of said each cellular region comprises a set of values for said parameter set.

4. The method of claim 3 wherein said each cellular region representation is defined as a cosinusoidal waveform.

5. The method of claim 3 or claim 4 wherein said parameter set comprises parameters of wavelength, angle and phase.

6. The method of any of claims 3 to 5 wherein said each cellular region representation has a set of values for said parameter set different from that of all other cellular region representations of said set of cellular region representations.

7. The method of any of claims 1 to 6 further comprising down-sampling said image to produce a down-sampled image prior to said sub-dividing.

8. The method of any of claims 1 to 7 further comprising storing each selected one of said set of cellular region representations in order to store a representation of said image.

9. The method of any of claims 1 to 8 wherein each of said cellular regions has identical dimensions.

10. The method of any of claims 1 to 9 further comprising associating a quality parameter with one or more of said cellular regions.

11. The method of any of claims 1 to 10 wherein said image comprises a biometric.

12. The method of claim 11 wherein said biometric is a fingerprint.

13. A computer readable medium containing computer executable instructions which, when loaded into a processor, cause said processor to:

provide a stored set of cellular region representations;

sub-divide said image into a plurality of cellular regions;

for each cellular region:

compare image information of said each cellular region to each cellular region representation of a plurality of said cellular region representations and,

based on said comparison, select one cellular region representation from said set of cellular region representations to represent said each cellular region.

14. Apparatus for obtaining a representation of an image, comprising:

a database storing a set of cellular region representations;

an image input;

a processor operatively coupled to said image input and said database, said processor for:

sub-dividing said image into a plurality of cellular regions;

for each cellular region:

compare image information of said each cellular region to each cellular region representation of a plurality of said cellular region representations and,

based on said comparison, selecting one cellular region representation from said set of cellular region representations to represent said each cellular region.

15. A method of obtaining a representation of an image, comprising:

providing a stored set of cellular region representations, each cellular region representation comprising a set of values for a parameter set;

sub-dividing said image into a plurality of cellular regions;

for each cellular region:

obtaining a cellular region set of values for said parameter set for said each cellular region and comparing said cellular region set of values to each cellular region representation of a plurality of said cellular region representations and,

based on said comparison, selecting one cellular region representation of said set of cellular region representations to represent said each cellular region.